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#14 Appeal Brief SDavis 5/7/03

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

IN RE APPLICATION OF :

Ende SHAN, et al. : EXAMINER: TOLEDO, F.

SERIAL NO.: 09/688,817 : GROUP ART UNIT: 2823

FILED: OCTOBER 17, 2000 :

FOR: LOW TEMPERATURE METALLIZATION PROCESS :



## APPEAL BRIEF

ASSISTANT COMMISSIONER FOR PATENTS
WASHINGTON, D.C. 20231

SIR:

The following is an appeal of the Examiner's final rejection of November 1, 2002, of Claims 1-20 and 22-24. A Notice of Appeal along with a petition for a one-month extension of time was timely filed on February 28, 2003.

## REAL PARTY IN INTEREST

The real party in interest is Cypress Semiconductor Corporation, by assignment recorded at reel/frame 9212/0623-0625.

## RELATED APPEALS AND INTERFERENCES

Appellants, Appellants' legal representative and the Assignee are not aware of any related appeals and interferences which will directly affect or be directly affected, or have a bearing on the Board's decision in the pending appeal.

## STATUS OF CLAIMS

Claims 1-24 are active in this application. Only claims 1-20 and 22-24 are herein appealed.

## STATUS OF AMENDMENTS

One amendment, canceling claim 21 was requested on December 30, 2002. The Advisory Action of January 31, 2003 indicated that Appellant's amendment would not be entered as "they are not deemed to place the application in better form for appeal by materially reducing or simplifying the issues for appeal." Claim 21 remains active in this application, however, is not herein appealed.

A copy of the claims herein appealed, as presently amended, is attached as an appendix.

## SUMMARY OF THE INVENTION

The present invention is directed to a method of forming a layer of metal on a substrate (page 4, lines 4-11, page 12, lines 2-5 and 18).

During the formation of semiconductor devices, metallization layers are generally formed in trenches and openings to form interconnects and vias. Formation of such metal layers can sometimes be complicated by difficulties with the conductivity of the metallization layers as a result of too rapid of a processing speed and accordingly rapid yet efficient methods for forming such metallization layers of good conductivity are sought.

The present invention addresses the problem by providing a method of forming a layer of metal on the substrate which comprises depositing onto a seed layer of metal which is formed on a surface, at a substrate temperature of from 220 to 300°C, depositing an

amount of metal under conditions sufficient to inhibit the formation of resistive metal phases having a resistivity greater than that of said metal, followed by depositing a further amount of metal. Appellants discovered that a process in which metal which is deposited onto a seed layer of metal is formed at a substrate temperature of from 220-300°C is effective in a method of forming a layer of metal on a substrate. More specifically, Appellants have discovered that such a seed layer allows for the deposition of metal on said seed layer under conditions that are sufficient to inhibit formation of resistive metal phases having a resistivity greater than that of said metal. Thereafter, additional metal may be deposited rapidly, without impairing the conductivity of the final metallization structure. The result is a metal structure having good conductivity properties which is formed in an efficient manner. Such a method is nowhere disclosed or suggested in the prior art of record.

## ISSUES

1. Whether the method of claims 1-20 and 22-24 are obvious over Xu U.S. 6,217,721 within the meaning of 35 U.S.C. §103(a).

2. Whether the method of claims 1-20 and 24 are obvious over claims 1-24 of U.S. 6,140,228 under the judicially created doctrine of obviousness-type double patenting.

3. Whether the method of claims 22 and 23 are obvious over claims 1-24 of U.S. 6,140,228 in view of Xu under the judicially created doctrine of obviousness-type double patenting.

## GROUPING OF CLAIMS

With respect to issue 1, the claims are grouped as follows:

group I, claims 1-4, 7-9, 11, 13, 16-18 and 20;

group II, claims 22 and 23;

group III, claim 24;

claims 5, 6, 10, 12, 14, 15 and 19 will be argued separately and do not stand or fall together or with any of the claims of groups I, II or III.

With respect to issue 2, the claims stand and fall together.

With respect to issue 3, the claims 22 and 23 stand and fall together.

## ARGUMENTS

Issue 1:

Claims 1-20 and 22-24 have been rejected under 35 U.S.C. § 103(a) over Xu U.S. 6,217,721.

The examiner has committed reversible error by concluding that each of Appellants' claim limitations are taught by the cited references.

Group I:

This group is directed to an embodiment in which a metal layer is deposited on a seed layer covering a substrate surface which is Ti, in which 1) the first amount of metal is deposited at a substrate temperature and power sufficient to inhibit formation of a filamentous metal phases and inhibit void formation in an opening having an aspect ratio of at least 2.0; 2) the seed layer is deposited at a substrate temperature of 220 to 300°C; and 3) a further amount of metal is deposited on the surface of the metal deposited on the seed layer.

Xu fails to disclose or suggest a method in which the first amount of metal is deposited at a substrate temperature and power sufficient to inhibit formation of a filamentous metal phases having a resistivity greater than that of the metal and inhibit void formation in an opening having an aspect ratio of at least 2.0. Xu also fails to disclose or suggest a method in which a seed layer is deposited onto a substrate surface which is Ti at a

substrate temperature of from 220-300°C. In addition, the cited reference fails to disclose or suggest a method in which metal is deposited on a seed layer, followed by deposition of a further amount of metal.

*Xu fails to disclose or suggest a method in which the first amount of metal is deposited at a substrate temperature and power sufficient to inhibit formation of a filamentous metal phases having a resistivity greater than that of the metal and inhibit void formation in an opening having an aspect ratio of at least 2.0*

Xu fails to disclose or suggest depositing the second amount of metal at a substrate temperature and power sufficient to inhibit formation of a filamentous metal phases having a resistivity greater than the metal and to inhibit void formation.

Quite simply Xu does not describe substrate power conditions for the deposition of the metal layer in any great detail and is completely silent as to using conditions which can inhibit the formation of filamentous phases having a resistivity greater than that of the metal. The deposition conditions for depositing the metal onto the seed layer are not described in any detail. Neither of process examples 1 or 2 describe the deposition of the Al metal layer. At column 8, lines 25-28 is a simple description of a two-step process, first a cold deposition and then a hot deposition. At column 24, lines 44-61 is a further description of forming a seed layer at low-temperature, followed by a hot deposition. There is a further description of adjusting the DC target power to deposit the 800 nm of hot aluminum in the given time. There is no description of adjusting the substrate power sufficient to inhibit the formation of filamentous metal phases having a resistivity greater than that of the metal. There is no description of the deposition conditions whatsoever in terms of the formation of filamentous metal phases having a greater resistivity than the metal being deposited. Therefore, in the absence of any specific deposition condition and the absence of any recognition of the prevention of the formation of filamentous metal phases having a greater resistivity than the metal being deposited the cited reference can not render obvious the claimed process. The

claim limitation of "a substrate temperature and power that are sufficient to (i) inhibit formation of filamentous metal phases having a resistivity greater than that of said metal, and (ii) provide a metal diffusion rate and a metal deposition rate sufficient to inhibit void formation in an opening having an aspect ratio of at least 2.0" is a claim limitation which is simply not found in the cite reference and accordingly, the claimed invention can not be found to be rendered obvious thereby.

*Xu Fails to Suggest Depositing a Seed Layer on a Substrate Surface of Ti at a Temperature of 220 to 300°C*

Xu describes a method, in which a via hole is filled, by cold deposition of a seed layer of Al onto a Ti substrate by sputtering, at a substrate temperature of **only 130°C** or lower, illustrated at column 20, line 11. The reference teaches the preferred cold deposition temperature of a seed layer of Al onto Ti to be **200°C or below** as the dewetting temperature is 250°C (column 24, lines 58-60). Accordingly, the reference expresses a preference for a temperature which is below 220° and explains the reasons as at higher temperatures undesired dewetting of the metal occurs.

The examiner agrees that Xu teaches a temperature of **only 200°C** (page 6 of office action November 1, 2002). The examiner has previously argued that a temperature of from 220 to 300°C as claimed would have been obvious as such a temperature would have been identified as the optimum or workable range, and only require routine experimentation (page 6, lines 4-13 of the official action of November 1, 2002).

The examiner argues for the first time, in the Advisory Action of January 3, 2003, that a temperature range of 50 to 250 °C is taught in the reference of Wang U.S. 5,108,570 which is cited in the disclosure of Xu (column 24, lines 11-12).

The reference of Wang is not of record in this case and no rejection based on Wang has ever been made. Morever, the disclosure in Xu which makes reference to Wang is not specifically directed to the deposition of metal onto a surface of Ti. The reference to Wang does not suggest a surface to deposit onto at all. The reference to Wang is simply the identification of a known cold-hot deposition condition. Xu further identifies cold-hot deposition conditions as taught by Ong as 50 to 150° cold and 550°C hot. Neither of these references is specific to cold-hot deposition onto a surface of Ti.

The cited portions merely describe exemplary cold-hot deposition condition such as 1) a cold deposition temperature of 50 to 150°C with a hot step of 550°C; and 2) a cold step of 50 to 250°C with a hot step not to exceed 400°C. These deposition temperature conditions are not suggestive for the method of Xu, as Xu specifically describes in the next sentences that

> "Wang does not give good data for the minimum temperature of the hot deposition and there is not suggestion that it can be much lower than 400°C. However, we have found that the liner layer allows the hot sputter to be performed at a substantially lower temperature, especially if reasonably short PVD deposition timesr are required." column 24, lines 13-18

Therefore, the reference acknowledges that the cited references are merely demonstrative of the possible temperature conditions for cold-hot deposition, yet recognized the limitations of such a general teaching and identifies preferential temperature conditions for these specific conditions.

As such, this portion of the reference is not suggestive of depositing a seed layer at a substrate temperature of 220 to 300°C followed by depositing a second amount of metal under conditions that are sufficient to inhibit formation of filamentous metal phases having a resistivity greater than that of the metal and provide a metal diffusion rate and a metal

diffusion rater and a metal deposition rate sufficient to inhibit void formation in an opening having ans aspect ratio of at least 2.0 followed by deposition of a further amount of metal.

Accordingly, these general references would not suggest to those of skill in the art cold-hot deposition onto a surface of Ti, as Xu provides specific deposition conditions of not more than 200°C for this situation. The examiner has committed reversible error, by relying on general teaching and ignoring the more specific teachings of the reference.

Moreover, it would not have been obvious to have selected a temperature of 220 to 300°C, as the result of optimization, as 1) the reference teaches that the temperature should **not** exceed 200°C as dewetting occurs at higher temperature; and 2) temperature is not identified as a result effective variable capable of being optimized for a particular result.

As to the first point, the reference identifies a preferred temperature of **200°C or below** as, at a temperature of 250°C, dewetting occurs. The teaching of a preferred temperature range of 200°C or below, with an express teaching of undesired consequences from exceeding the preferred temperature range does not provide any motivation to exceed the temperature range of below 200°C.

> However, while it may ordinarily be the case that the determination of optimum values for the parameters of a prior art process would be at least *prima facie* obvious, that conclusion depends upon what the prior art discloses with respect to those parameters. Where, as here, the prior art disclosure suggests the outer limits of the range of suitable values, and that the optimum resides within that range, and where there are indications elsewhere that in fact the optimum should be sought within that range, the determination of optimum values outside that range may not be obvious. We think it is not on the facts of this case (In re Sebek, 175 USPQ 93, 95 (CCPA 1972)).

The reference identifies the range of below 200°C as preferable for this process step and further identifies undesired results from **exceeding** the preferred range of 200°C. Contrary to the assertions in the official action, those of ordinary skill in the art would not be motivated to exceed a temperature of below 200°C, as the reference clearly identifies reasons

not to exceed this temperature. Why would one be motivated to use a temperature which is suggested to increase the likelihood of dewetting? There simply is no motivation to increase the temperature in view of the express negative results from higher temperature. As a matter of law there is no motivation to exceed the identified range of below 200°C.

As to the second point, it was suggested by the examiner that the claimed temperature range of 220 to 300°C, would have been the obvious result of optimization. Appellants respectfully submit that there is no suggestion to optimize the temperature of the cold deposition process step to be within the range of 220 to 300°C, as there is no teaching that a higher temperature is a result effective variable.

> A particular parameter must first be recognized as a result-effective variable, i.e., a variable which achieves a recognized result, before the determination of the optimum or workable ranges of said variable might be characterized as routine experimentation. *In re Antonie* 195 USPQ 6, (CCPA 1977) (MPEP 2144.05)

In the present case there is no identification of a recognized desired result from adjustment of the temperature and therefore there can be no motivation to optimize the deposition temperature to within the range of 220 to 300°C. Where is the motivation to adjust the temperature range beyond the identified range of below 200°C? What desired result would be achieved by adjustment of the cold deposition temperature to be optimum? Since there is no identified desired result from the cold deposition temperature, as a matter of patent law there is no suggestion to optimize the cold deposition temperature and therefore the claimed temperature range of 220 to 300 °C is not obvious.

In contrast, the present invention is directed to a process in which a seed layer of metal, which may be Al, is formed on a first substrate surface which is Ti, at a substrate temperature of from 220-300°C. The claims recite deposition onto a surface which is Ti, **at a substrate temperature of from 220-300°C**.

As the cited reference provides no disclosure or suggestion of the claimed substrate temperature range of 220 to 300 °C the claimed invention is neither anticipated nor obvious over the cited reference.

*Xu Fails to Disclose or Suggest a Method in Which the Metal Is Deposited on a Seed Layer in at Least Two Steps.*

The examiner commits reversible error in concluding the claimed invention to be obvious in view of the reference of Xu which fails to disclose a process in which metal is deposited onto a seed layer in at least two steps.

As previously described Xu describes a cold-hot sputtering process in which a seed layer is formed by a cold sputtering process followed by **a single** hot sputtering process. Only a single deposition step is described after formation of the seed layer by cold sputtering.

In contrast, the claimed invention is practiced by depositing an amount of metal onto a seed layer of metal, **followed by deposition of a further amount of metal** (e.g. step iii of claim 1). The claim limitation of depositing a further amount of metal onto the surface of the metal deposited onto the seed layer of metal, is a claim limitation which is not found in the cited reference. The examiner commits reversible error by concluding the claimed invention to be obvious, when the reference clearly fails to disclose or suggest Appellants' claim limitation of depositing a further amount of metal onto the surface of the metal deposited onto the seed layer of metal.

In his rejections, the examiner points to figures 16 and 17 as teaching the claim limitation of depositing a further amount of metal onto the surface of the metal deposited onto the seed layer of metal. No such teaching is found in these two illustrations which simply illustrate a via hole (fig 16) and a via hole after its metallization (fig 17). There is no suggestion from these figures or in the specification of depositing the metal in at least two portions onto the seed layer of metal.

For at least these reasons the decision of the primary examiner must be reversed.

Group II:

This group (claims 22-23) is directed to an embodiment in which a metal layer comprising aluminum is deposited on a seed layer of aluminum covering a substrate surface which comprises Ti, in which 1) the seed layer is deposited at a substrate temperature of 220 to 300°C; 2) a further amount of metal is deposited on the surface of the metal deposited on the seed layer; and 3) the first amount of metal is deposited at a substrate power sufficient to inhibit formation of a resistive $TiAl_3$ phase.

Xu fails to disclose or suggest that the seed layer is deposited at a substrate temperature of from 220 to 300°C and the deposition of a further amount of metal on the surface of the metal deposited on the seed layer. The reasons are discussed in the arguments in support of group I. same as group I

Moreover, Xu fails to disclose or suggest depositing the first amount of metal at a substrate power sufficient to inhibit formation of a phase of $TiAl_3$ having a resistivity greater than that of the metal. same as group I on the power supply

Quite simply Xu does not describe substrate power conditions for the deposition of the metal layer in any great detail and is completely silent as to using conditions which can inhibit the formation of a phase of $TiAl_3$ having a resistivity greater than that of the metal. The deposition conditions for depositing the metal onto the seed layer are not described in any detail. Neither of process examples 1 or 2 describe the deposition of the Al metal layer. At column 8, lines 25-28 is a simple description of a two-step process, first a cold deposition and then a hot deposition. At column 24, lines 44-61 is a further description of forming a seed layer at low-temperature, followed by a hot deposition. There is a further description of adjusting the DC target power to deposit the 800 nm of hot aluminum in the given time.

There is no description of adjusting the substrate power sufficient to inhibit the formation of a phase of $TiAl_3$ having a resistivity greater than that of the metal. There is no description of the deposition conditions whatsoever in terms of the formation of phases having a greater resistivity than the metal being deposited. Therefore, in the absence of any specific deposition condition and the absence of any recognition of the prevention of the formation of phases having a greater resistivity than the metal being deposited the cited reference can not render obvious the claimed process. The claim limitation of "a substrate power sufficient to inhibit formation of a phase of $TiAl_3$ having a resistivity greater than that of said metal" is a claim limitation which is simply not found in the cite reference and accordingly, the claimed invention can not be found to be rendered obvious thereby.

<u>Group III:</u>

This group is directed to an embodiment in which a substrate power sufficient to inhibit formation of a phase containing the metal, having a resistivity greater than that of said metal.

<u>Xu</u> fails to disclose or suggest that the seed layer is deposited at a substrate temperature of from 220 to 300°C and the deposition of a further amount of metal on the surface of the metal deposited on the seed layer. The reasons are discussed in the arguments in support of group I.

Moreover, <u>Xu</u> fails to disclose or suggest depositing the first amount of metal at a substrate power sufficient to inhibit formation of a phases of the metal having a resistivity greater than that of the metal.

Quite simply <u>Xu</u> does not describe substrate power conditions for the deposition of the metal layer in any great detail and is completely silent as to using conditions which can inhibit the formation of a phase of the metal having a resistivity greater than that of the metal.

The deposition conditions for depositing the metal onto the seed layer are not described in any detail. Neither of process examples 1 or 2 describe the deposition of the Al metal layer. At column 8, lines 25-28 is a simple description of a two-step process, first a cold deposition and then a hot deposition. At column 24, lines 44-61 is a further description of forming a seed layer at low-temperature, followed by a hot deposition. There is a further description of adjusting the DC target power to deposit the 800 nm of hot aluminum in the given time. There is no description of adjusting the substrate power sufficient to inhibit the formation of a phase of $TiAl_3$ having a resistivity greater than that of the metal. There is no description of the deposition conditions whatsoever in terms of the formation of phases having a greater resistivity than the metal being deposited. Therefore, in the absence of any specific deposition condition and the absence of any recognition of the prevention of the formation of phases having a greater resistivity than the metal being deposited the cited reference can not render obvious the claimed process. The claim limitation of "a substrate power sufficient to inhibit formation of a phase containing said metal having a resistivity greater than that of said metal" is a claim limitation which is simply not found in the cite reference and accordingly, the claimed invention can not be found to be rendered obvious thereby.

Claim 5:

This claim is directed to a deposition rate of metal in step ii) of 5 to 30 Å/sec. Such a deposition rate is nowhere disclosed or suggested in the reference and accordingly, this claim is independently patentable. The examiner cites to Figure 15 as rendering this claim obvious. However, this figure merely provides a graph of the processing window for PVD of aluminum, relative to time and temperature. A rate of deposition is nowhere suggested.

Claim 6:

This claim is directed to deposition conditions for the second amount of metal of a pressure of 4 to 6 mtorr. Such a pressure is nowhere disclosed or suggested in the reference and accordingly, this claim is independently patentable. The examiner agrees that this limitation is not suggested however asserts that in view of the specific teaching of 0.5 to 2 mtorr, that the range of 4 to 6 mtorr would have been obvious. The examiner commits clear error in ignoring the specific teachings of the reference of 0.5 to 2 mtorr. There is no general teaching of any deposition pressure, but rather there is only a specific teaching of a pressure range outside of the claimed range. As a matter of law the examiner has not shown this claim limitation to be obvious and accordingly, the claim is not obvious.

Claim 10:

This claim is directed to a power for deposition of the seed layer of 9,000 W. Such a power is nowhere disclosed or suggested in the reference and accordingly, this claim is independently patentable. The examiner cites to column 15 as rendering this claim obvious. However, this simply describes deposition conditions for Ti and TiN which are used to form the liner layer, not the metal layer. A power for the deposition of the seed layer is nowhere suggested.

Claim 12:

This claim is directed to a deposition rate for the seed layer of metal in step i) of 100 to 300 Å/sec. Such a deposition rate is nowhere disclosed or suggested in the reference and accordingly, this claim is independently patentable. The examiner cites to column 20 as rendering this claim obvious. However, this section describes a deposition rate for the materials used in the liner layer and not the seed layer. A deposition rate as claimed is simply not suggested by the reference.

Claim 14:

This claim is directed to heating of the substrate during the second step by backside gas flow. A process of heating by backside gas flow is not suggested in the reference and accordingly this claim is individually patentable. The examiner cites to column 11 as rendering this claim obvious. However this merely recites the presence of Ar as a background gas and does not suggest heating with a backside gas flow.

Claim 15:

This claim is directed to heating of the substrate during the second step by backside gas flow of Ar gas. A process of heating by backside gas flow of Ar is not suggested in the reference and accordingly this claim is individually patentable. The examiner cites to column 11 as rendering this claim obvious. However this merely recites the presence of Ar as a background gas and does not suggest heating with a backside gas flow of Ar.

Claim 19:

This claim is directed to a power for deposition of the second amount of metal of 100 to 800 W. Such a power is nowhere disclosed or suggested in the reference and accordingly, this claim is independently patentable. The examiner cites to column 20 as rendering this claim obvious. However, this simply describes deposition conditions for Ti and TiN which are used to form the liner layer, not the metal layer. A power for the deposition of the second amount of metal is nowhere suggested.

Issue 2:

Claims 1-21 and 24 have been rejected under the judicially created doctrine of obviousness-type double patenting over Claims 1-24 of U.S. 6,140,228.

U.S. '228 does not claim deposition onto a liner layer which is Ti nor does it claim deposition of a seed layer at a temperature of from 220-300°C. As such, the claimed invention is clearly not obvious under the judicially created doctrine of obviousness-type

double patenting as the claim limitations of a Ti liner layer and a seed layer deposition temperature of from 220-300°C are not disclosed or suggested in the reference. In order to support a rejection for obviousness-type double patenting, there must still be a disclosure or suggestion of each and every claim limitation.

> We decline to extract from Merck the rule that the Solicitor appears to suggest -- that regardless of how broad, a disclosure of a chemical genus renders obvious any species that happens to fall within it. In re Jones 21 USPQ2d 1941 (Fed. Cir. 1992)

The absence of the disclosure or suggestion of the Ti liner layer or the deposition temperature of 220 to 300°C precludes a conclusion of obviousness-type double patenting. Accordingly, the examiner's rejection under the judicially created doctrine of obviousness-type double patenting is in error and must be reversed.

Issue 3:

Claims 22-23 have been rejected under the judicially created doctrine of obviousness-type double patenting over claims 1-24 of U.S. 6,140,228 in view of Xu.

These claims are directed to a method of forming a layer of Al on substrate surface comprising titanium, in which the seed layer is formed at a substrate temperature of 220 to 300°C.

U.S. '228 in combination with Xu does not disclose a seed layer formed at a temperature of from 220-300°C. As such, the claimed invention is clearly not obvious under the judicially created doctrine of obviousness-type double patenting as the claim limitation of a seed layer deposition temperature of from 220-300°C is not disclosed or suggested in the reference. In order to support a rejection for obviousness-type double patenting, there must still be a disclosure or suggestion of each and every claim limitation.

> We decline to extract from Merck the rule that the Solicitor appears to suggest -- that regardless of how broad, a disclosure of a chemical genus renders obvious any species that happens to fall within it. In re Jones 21 USPQ2d 1941 (Fed. Cir. 1992)

The absence of the disclosure or suggestion of the deposition temperature of 220 to 300°C precludes a conclusion of obviousness-type double patenting. Accordingly, the examiner's rejection under the judicially created doctrine of obviousness-type double patenting is in error and must be reversed.

Appellants submit this application is now in condition for allowance and early notification of such action is earnestly solicited.

Respectfully submitted,

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